MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, SESSION 2015/2016

EEL4126 – POWER SYSTEM OPERATION AND CONTROL

(LE)

13 OCTOBER 2015
9:00 AM – 11:00 AM
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This Question Paper consists of four pages including the cover page with four Questions only.

2. Answer **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please print all your answers in the Answer Booklet provided.

Question 1

(a) A thermal power plant consisting of n generating units supplies power to a total load of P_D MW. The fuel-cost function of unit i in \$/h is given by

$$C_i = \alpha_i + \beta_i P_i + \gamma_i P_i^2$$

where P_i is the power generation of unit i in MW. Show that the power generation P_i for optimal dispatch neglecting the transmission line losses is given by

$$P_i = \frac{\lambda - \beta_i}{2\gamma_i} \text{ where } \lambda = \frac{P_D - \sum_{i=1}^{n} \frac{\beta_i}{2\gamma_i}}{\sum_{i=1}^{n} \frac{1}{2\gamma_i}}$$

[10 marks]

(b) The fuel-cost functions of three thermal power plants in \$/h are:

$C_1 = 500 + 5.3\ P_1 + 0.004P_1^2$

$C_2 = 500 + 5.5\ P_2 + 0.006P_2^2$

$C_3 = 500 + 5.8\ P_3 + 0.009P_3^2$

P_1, P_2, and P_3 are in MW. The total power demand, P_D =1000 MW. Find the optimal dispatch neglecting the line losses and the total cost with the following generator limits in MW.

$200 \le P_1 \le 450$; $150 \le P_2 \le 400$; $100 \le P_3 \le 300$

[9 marks]

(c) Define the following terms related to unit commitment

(i) Minimum up time [1.5 marks]

(ii) Minimum down time [1.5 marks]

(iii) Start-up cost [1.5 marks]

(iv) Hydro constraint [1.5 marks]

Question 2

(a) Discuss the usefulness of sensitivity factors in contingency analysis of a power system. [4 marks]

(b) Define generation shift factor and derive an expression for it in terms of elements of X-matrix used in DC power flow. [6 marks]

Continued...

(c) A 3-bus power system is shown in Fig.Q2. The line reactances are: x_{12} = 0.2pu, x_{13} = 0.4pu, and x_{23} = 0.25pu. Bus 3 is the reference bus. The base loads and generations are

Bus	Load (pu)	Gen. (pu)
1	1.0	1.5
2	3.0	1.8
3	1.0	1.7

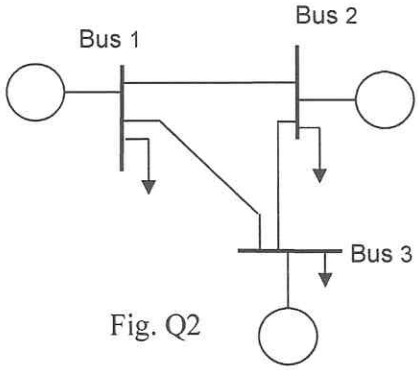

Fig. Q2

(i) Compute X-matrix for DC power flow. [5 marks]
(ii) Find the base power flows on the transmission lines. [5 marks]
(iii) Calculate the generation shift factors for line 1-2 for a change in Generation on bus 1. [2 marks]
(iv) Calculate the shift in generation on bus 1 so as to force the flow in line 1–2 to zero. [3 marks]

Question 3

(a) Two generators and a load are connected to a bus. The MVA rating and the speed droop R of each generator are given below.

Generator	MVA rating	R (pu on generator base)
1	100	0.01
2	500	0.015

The initial loads on the generators are:

P_1 = 100 MW; P_2 = 300 MW;

Determine the new generation in each unit if the load increase is 50 MW. Assume that the system frequency is 50 Hz. [7 marks]

(b) Draw a block diagram of an isolated power system consisting of governor, prime mover and rotating mass & load models and explain the functions of each block. Assuming single-time constant transfer function for each block, obtain the overall transfer function relating the load change to the frequency change. [12 marks]

(c) A two-area power system is connected by a tie line with the following characteristics.

Area 1: R = 0.01 pu D = 0.8 pu Base MVA = 500
Area 2: R = 0.02 pu D = 1.0 pu Base MVA = 500

A load change of 100 MW occurs in area 1. What is the steady-state frequency and what is the change in tie flow? Assume both areas were at nominal frequency of 50 Hz to begin with. [6 marks]

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Question 4

(a) Draw a functional block diagram of a large synchronous machine excitation system and explain the function of each block. [10 Marks]

(b) State the various types of excitation systems used for synchronous machines. [3 marks]

(c) Load curve data of a power system with three generating units is given below.

Period Time	Period 1 3 hours	Period 2 3 hours	Period 3 4 hours	Period 4 4 hours
Load (MW)	350	600	400	900

The following are data pertaining to three generating units.

Unit 1: $C_1 = 561.0 + 7.92\ P_1 + 0.001562\ P_1^2$ RM/h and Max power = 600 MW

Unit 2: $C_2 = 310.0 + 7.85\ P_2 + 0.001940\ P_2^2$ RM/h and Max power = 400 MW

Unit 3: $C_3 = 100.0 + 9.56\ P_3 + 0.005784\ P_3^2$ RM/h and Max power = 250 MW

(i) Obtain the priority list based on full-load average production cost. [4 marks]

(ii) Find the unit commitment using Priority List Algorithm. The minimum start-up cost of unit 1 is RM2000. Ignore minimum up and down time. [8 marks]

End of Paper.